THE AUTHORS' REPLIES TO THE DISCUSSION BEFORE THE INSTITUTION

Messrs. T. C. Macnamara and **D. C. Birkinshaw** (*in reply*): Sir Noel Ashbridge mentioned one or two economic differences between sound broadcasting and television, and in this connection it is interesting to compare the present situation as regards rehearsals. In the case of a production over the sound broadcasting system some 5 hours of rehearsal are necessary per hour of transmission. It will be at once evident that in the case of television at least this, and preferably a greater, ratio of rehearsal to transmission time is required, since the rehearsal involves, in addition, the setting of lights, considerations of make-up and costume, and, moreover, artists cannot read their parts from scripts. At present, rehearsal/transmission time ratios of only 1 or 2 to 1 are being realized, and although a great deal can be done by means of preliminary rehearsals conducted without apparatus, it is essential, if the standard of presentation is to be improved, for facilities to be provided enabling more rehearsal time to be spent in the studio. It is primarily for this reason that a second studio has recently been put into service, and a third is at present in the course of being prepared at the Alexandra Palace.

Mr. Gill referred to the work that the B.B.C. is doing on the use of telephone circuits for television purposes. In this connection it is interesting to note that it has already been found possible to send vision signals over a length of 4 miles of ordinary telephone circuit. The technical arrangements necessitated the use of special terminal equipment, and of two intermediate repeaters with equalizers installed at the two Post Office exchanges en route. It was, however, unnecessary to interfere with the lines themselves. We should like to record the fact that the London Telephone Service has been most helpful in providing the necessary facilities for experiment in this direction. The transmission of television signals over normal telephone circuits is considered to be a useful method of extending the number of possible television outside broadcasts which can be carried out with the aid of the balanced cable circuit, and, if successful results are consistently achieved, there will, no doubt, be ample justification for an extension of the balanced cable.

It is also considered that the potentialities of the radio link between outside broadcast points and the London Television Station are capable of further development, which should lead to an extension of the maximum distance from the Alexandra Palace at which it is now possible to handle such broadcasts, and which is now some 15 miles.

Mr. Marris raises an important point when he refers to the question of demonstrating television receivers to the public. The television receiver designed for home use cannot be successfully seen by a large number of people at once, and, where this is attempted, the overloading of the tube, due to the use of an excessive contrast adjustment, will inevitably give those nearest to the receiver an unfavourable impression of the picture. We consider that, with the receivers available at present, the maximum number of people who can simultaneously and satisfactorily see a picture is not much greater than 12.

Mr. Bedford very rightly refers to the difficulty created by the high cost of television programmes, and suggests as a remedy the " internationalization " of programmes. This is certainly an attractive possibility, but it is, of course, subject to many difficulties both technical and non-technical, the latter including the question of differences of languages. If the technical difficulties can be overcome, however, it might be found possible to devise a proportion of television programme material which would carry its entertainment value in the picture rather than in the sound, and would therefore be acceptable to an international audience.

Mr. Willans made reference to the question of interference from sources extraneous to the receiver, and is not optimistic as to the possibility of any improvement in this respect. In view of the fact that such interference largely emanates at present from motor-car ignition systems, it does seem to us that some amelioration of this difficulty could be obtained by negotiation and, possibly, by legislation. As regards the relative effect of the interference on the picture and on the synchronizing, the system was designed so that interference would manifest itself primarily on the picture, and that no serious effect on the synchronizing would be observed until the picture had been rendered unacceptable by interference. As a result of many observations it is considered that the design of the system is satisfactory in this respect.

Concerning Mr. Strafford's remarks upon the subject of reciprocity between aerial systems, we agree that further experimental work is needed to determine the conditions in which reciprocity applies to systems employing ultra-short waves. The point is rather that the absolute level of interference received with a high receiving aerial may be greater than with a low aerial. This is an entirely separate matter which may complicate the issue but has no bearing upon the principle of reciprocity, although the conclusion is that more favourable results are likely to be received with a high transmitting aerial and a low receiving aerial than vice versa.

Dr. Hughes made some observations upon the most desirable size of a received picture. It will be generally agreed that an increase of picture size is desirable but it should be remembered that this will bring certain problems to those responsible for the transmissions. It is already known that the studio technique which should be adopted in production is considerably influenced by the size of the reproduced picture. With the size at present available it is found desirable to employ what may be described as an intimate production technique, but observations which have been made with comparatively large received pictures show that such a technique

is not suitable for such pictures, and there is no doubt that when the public are generally equipped with large picture receivers the studio technique will be quite different from that employed to-day. An interesting problem therefore arises in the intermediate period when some viewers have provided themselves with modern large-picture receivers, while others still retain the types in use to-day.

Dr. Hughes also mentions the question of the B.B.C. " shooting " its own film. It is improbable that it will be found desirable to introduce film as an intermediate stage in the production of the general run of television programmes, but there is a considerable field in the employment of specially-taken films to supplement normal productions and introduce into them scenes which could not be conveniently set up in the studio. In this connection, it should be mentioned that the B.B.C. has for some time been " shooting " a considerable amount of film for this purpose.

Messrs. A. D. Blumlein, C. O. Browne, N. E. Davis, and **E. Green** (*in reply*): A number of speakers have raised the question of the best γ value to use, and the advisability of introducing preparatory signals before the frame-synchronizing signals. These points will be dealt with first, before the remarks of individual speakers are replied to.

Messrs. Gill, Hughes, and Wilson, have suggested that a lower γ value than unity might be used at the transmitter, and subsequently corrected at the receiver. It might be argued that the human eye has an almost logarithmic sensitivity and so desirably the transmitter modulation should be a logarithm of the original brightness, the receiver having an exponential characteristic so that background "noise" would be equally noticeable at all levels. However, for a picture viewed as a whole, the eye does not appear to have logarithmic sensitivity as regards noticing low-level interference. If a television picture is examined with low-level interference introduced in such a manner as to be modified by a γ of about 2 when converted to light intensities, it will be noticed that the interference is hardly more noticeable in the blacks than in the whites, provided, of course, that the focus is maintained for the high lights. This latter requirement is important since in practice the surface noise in the high lights is usually obliterated by the less perfect focus of the cathode-ray tube. This leads to the conclusion that a slight theoretical improvement might be obtained by working with a transmitted γ slightly less than unity. The practical return would be almost negligible since near the optimum the curve of advantage is flat-topped. Further, it must be remembered that a very high γ at the receiver makes intense interference (such as motor-car interference) appear very objectionable.

Messrs. Marris, Willans, Spratt, and Wilson, have asked for preparatory signals before the frame-synchronizing signal. Mr. Davies does not want them, nor presumably does Mr. Bedford. It must be pointed out again that we know of only one type of circuit which is the better for preparatory signals, whereas there are a number of circuit types where such signals are quite unnecessary. Mr. Willans has referred to one, and Mr. Davies has pointed out the extremely elegant type due to Mr. Fairhurst. Using the integrating-type circuit without preparatory pulses, the interlace is slightly misplaced, but our practical experience is that any real trouble in interlacing is usually due to coupling between the scanning generators, which would be completely unaffected by the preparatory signals. Mr. Spratt has suggested two lines of preparatory signals, whereas apparently Mr. Willans requires perfection. To give a good result with a true integrating circuit (very long time-constant) a very large number of preparatory lines are required, perfection being achieved when the whole frame period is used in preparation for the frame-synchronizing pulse and no time is wasted in picture transmission. In practice a fair number of lines must be utilized for preparatory pulses if they are to be worth sending at all. This time is therefore wasted, as it is not used either to accommodate the receiver flyback or to give the receiver time to recover from any slight upset of line scanning due to the latter having been triggered by frame-synchronizing pulses. Mr. Willans is astonished that an attempt should be made to improve the efficiency by 5 % by reducing the frame interval from 20 to 10 lines, whereas Mr. Condliffe is sure that a change from 405 to 441 lines would produce no noticeable improvement of picture. Of course, such a change accompanied by a 20 % increase of band width would give a better picture. However, for a given band width (be it that appropriate to 405 or to 441) a 10 % change in number of lines would slightly interchange horizontal and vertical definition, and would produce negligible change in picture quality. The increase of 10 picture lines in each frame means a 5 % improvement without increase of band width.

Mr. Willans finally points out that the new U.S.A. television standards include preparatory pulses not only before but gratuitously after the frame-synchronizing pulses, and that this standard is presumably the result of much consideration. It is to be noted that the new German standard,* presumably decided upon after similar consideration, does not employ any preparatory pulses. Mr. Ballard's patent may appear sanguine but it has the right idea, and it must be repeated that the practical difficulties are usually due to stray couplings which prevent the scanning generators running uniformly as required by the Ballard arrangement.

It was appreciated that it would be possible to construct a mechanical film transmitter, but the correcting circuits to which Mr. Marris refers for the Emitron film transmitter are already part of the system and are used, of course, for all cameras. The Emitron film transmitters are synchronized from a centralized source of timing signals so that they may be mixed with the studio cameras if required, whereas it is well-nigh impossible to synchronize a mechanical transmitter with sufficient accuracy to provide the same facility. A solution to this difficulty is to use the mechanical transmitter as the source of timing signals, but, even so, the immediate disadvantages are obvious, and this method does not lend itself kindly to an extension of the television station with further studios each with the necessary camera control equipment.

Mr. Marris has suggested a consideration of amplitude selection for frame- and line-synchronizing signals. This

* D. von Oettingen, R. Urtel, and G. Weiss: *T.F.T.*, 1938, vol. 27, p. 158.

system demands that not only must the vision signals lie totally on the straight part of any amplifier, modulation, or detection characteristics, but similarly the synchronizing signals must lie on linear portions of the characteristic. With positive modulation using zero carrier for the larger synchronizing pulse, the modulation and detection are extremely difficult if the larger synchronizing pulse is not to be crushed. With negative modulation all the advantage of a simple line-to-line A.V.C. is abandoned.

In answer to Mr. Bedford's question regarding the relation of the Emitron to its American counterpart, the Iconoscope, it should be stated that these are trade names and apply to two entirely independent developments of the cathode-ray tube for transmitting images proposed by Campbell Swinton in 1908.*† Because the same fundamental principles are involved in the two tubes, it is not surprising that they should be generally similar in physical appearance, but the differences of the two tubes which are now known to exist are accounted for by the dissimilar methods adopted in their manufacture.

With regard to the " Super-Emitron," this is a further development of the Campbell Swinton idea, but it involves an entirely new principle and was first developed in the E.M.I. laboratories.‡ This new principle has been adopted in the American version of the tube, which has been called the " Super-Iconoscope."

Mr. Willans feels that negative modulation may still be the correct solution. As regards the tests referred to in the first part of the paper, the receivers used for testing negative modulation had no special limiter to limit interference in the receiver output to a value corresponding to the peak synchronizing amplitude. The time-base, however, was designed to be quasi-periodic, in that the scanning generators were only capable of being triggered by an incoming pulse shortly before the end of the scanned line. Even with a critical adjustment, interference tended to cause a " ragged " picture, even if incapable of seriously displacing the lines. It is agreed, of course, that suitable limiters can make negative and positive modulation practically equivalent, but such limiters are a necessity with negative modulation, and it is the cheap receiver (without A.V.C.) which must be kept cheap.

The impedance-matching of the circuits used in the modulation amplifiers for the mobile transmitter, to which Mr. Spratt refers, is carried out with the same care as for the modulation amplifiers described in this paper. The mobile transmitter, however, is of considerably lower power, and so requires less swing from the modulation amplifiers. It was therefore more economical to provide larger smoothing components and to increase the power-handling capacity of the amplifiers to produce the swing required, than to install a 500-cycle supply.

Mr. Wilson elaborates a method of d.c. establishment which is agreed to be essentially the same as that described in Reference (2) of the paper, but these and similar methods suffer from the disadvantage that the reference signal is generated at the edge of the picture where the tilting conditions are sometimes difficult. The method of establishment of the direct component from a black border as described in Reference (2) has been used experimentally for film transmission, and by using the circuits given in Reference (12) the result was obtained without the complication of the method Mr. Wilson proposes.

Mr. Wilson's argument for negative modulation appears to be that it provides a means by which the amplitude of the synchronizing signals can be checked in terms of the difference between black level and zero carrier, which incidentally cannot be peak white unless perfectly linear modulators and detectors are invented. There may be a use for three reference levels, but the use is not obvious.

As regards Mr. Wilson's final remark, it is pointed out in Section (*e*) of the Appendix to Part I that the 10 lines are a minimum interval, and in Section (*m*) that initially this minimum may be exceeded. Also, in Section (13) of Part I it is explained that ultimately it is hoped that the 10-line interval will be realized.

* *Nature*, 1908, vol. 78, p. 151.
† *Journal of the Röntgen Society*, 1912, vol. 8, p. 1.
‡ H. G. LUBSZYNSKI and S. RODDA: British Patent No. 412666.